Inter-American Development Bank

Assessing the Impacts of Market Failures on Innovation Investment in Uruguay

Institutions for Development Sector

Competitiveness, Technology, and Innovation Division

TECHNICAL NOTE Nº IDB-TN-1457

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Cataloging-in-Publication data provided by the
Inter-American Development Bank
Felipe Herrera Library

Bukstein, Daniel.
Assessing the impacts of market failures on innovation investment in Uruguay / Daniel Bukstein, Elisa Hernández, Ximena Usher.
p. cm. — (IDB Technical Note ; 1457)
Includes bibliographic references.
1. Business enterprises-Technological innovations-Uruguay. 2. Technological innovations-Economic aspects-Uruguay. 3. Technological innovations-Government policy-Uruguay. 4. Investments-Uruguay. 5. Labor productivity-Uruguay. I. Hernández, Elisa. II. Usher, Ximena. III. Inter-American Development Bank. Competitiveness, Technology and Innovation Division. IV. Title. V. Series
IDB-TN-1457

http://www.iadb.org

Abstract[*]

This paper analyzes the effects of financial and nonfinancial obstacles to innovation on Uruguayan firms. We contribute to the literature by including the role of systemic and institutional factors affecting the different stages of the innovation process. The empirical analysis is based on four waves of national innovation surveys covering firms in the industry and services sector. In line with recent studies, we confine our analysis to the relevant sample of potentially innovative firms. Our results show that market, financial, knowledge, and context obstacles are the most important factors reducing innovation propensity and the amount invested in innovation activities. The effects are similar for firms in the industry and services sectors. We do not find evidence that institutional factors hamper innovation. Investment in equipment and investment in R&D and other intangible activities are affected differently by obstacles. On the other hand, innovation outcomes are affected mainly by financial and market-related barriers. We do not find evidence that obstacles to innovation have a significant impact on labor productivity.

JEL codes: C23, O31, O32, O33
Keywords: CDM model, financial and non-financial barriers to innovation, innovative firms, Uruguay

[*] The authors thank Gustavo Crespi, Jocelyn Olivari, Fabrice Galia, and Maria Savona for helpful discussions and comments. We greatly appreciate the funding provided by the Inter-American Development Bank and the South American Network on Applied Economics/Red Sur for this research. The views expressed herein are those of the authors and do not reflect the official positions of the ANII. All remaining errors and limitations are our responsibility.

1. Introduction

In the last century, theoretical and empirical works have identified innovation (mainly proxied by R&D investment) as a key driving force of firm productivity and economic growth. Theoretically, since the pioneering work of Solow (1957), technological change has been credited with explaining a substantial share of economic growth, while empirical developments focusing on the relationship between R&D expenditure and productivity have flourished since the seminal work of Griliches (1979). Since then, several Latin American and Caribbean (LAC) countries have established and implemented public policies aimed at enhancing innovation (Crespi and Dutrénit, 2014). However, while much attention was paid to the determinants of firm's innovation and the impact of the policy actions to promote innovation on investment and firm productivity, the analysis of the factors behind the lack of engagement on innovation activities has been neglected.

Even though there are several studies that focus on innovation and Science and Technology (STI) policies in Uruguay (Bernheim et al., 2014; Aboal et al., 2015; Bukstein et al., 2017, among others), none of them focus on what prevents the firm from engaging in innovative activities or obtaining results from their innovation efforts. As Bianchi, Bianco, and Snoeck (2014) point out, Uruguayan policymakers lack information about obstacles hampering innovation in productive sectors. Exploring the factors hampering innovation is relevant in the design of policy interventions and the national systems of innovation (Woolthius, Lankhuizen, and Gilsing, 2005). The proper identification of which obstacles affect each part of the innovation process could encourage specific interventions that may lead to an increase in economic growth and development in the long run. In that sense, we expect that the evidence presented in this paper will become a key input in the future design of policy actions.

The main objectives of this study are: (i) to test and measure to what extent barriers hinder innovation in a developing country such as Uruguay, with a focus on context and institutional barriers; (ii) to compare whether the severity of the barriers vary across different economic sectors; and (iii) to compare whether barriers are relatively more important for tangible investments than intangible ones. We add to the literature of barriers to innovation in two ways. On one hand, we analyze the effect of barriers to innovation on the entire chain of the innovation process: innovation propensity, innovation intensity, innovation outputs, and labor productivity. We do so separately for firms in the industry sector and in the services sector. Secondly, we introduce a specific variable to measure how the institutional context affects the innovation process. This intends to shed some light on the effects of regulation and systemic factors affecting the firms' innovative behavior. We use a novel dataset covering all industries and some services of firms in the Uruguayan economy, which allows us to investigate the heterogeneous effects of barriers by sector and type of innovation.

We report that barriers to innovation have a substantial effect on innovation propensity, innovation intensity, and innovation outcomes. On the other hand, we do not find evidence that barriers affect labor productivity. The presence of obstacles to innovation translates to a reduction of 47 percent to 89 percent in the firms' innovation efforts; also, it translates to a reduction of 6.5 percent to 14 percent in the firms' innovation propensity. Financial, market, knowledge, and context obstacles are the most important factors distressing the innovation process, as they reduce the probability to engage in innovation activities and the amount invested as well as innovation outcomes. The results indicate that barriers affect firms in the industry and services sector in a similar way.

The paper proceeds as follows. Section 2 provides a brief review of the recent developments in the literature on barriers to innovation. In Section 3 we introduce the data and methodological aspects of the paper. Section 4 shows the results of the econometric exercises; finally, Section 5 concludes.

2. Literature Review

The empirical literature analyzing obstacles to innovation in the past decades was dedicated mostly to the role of financial constraints (Himmelberg and Petersen, 1994; Bond, Harhoff, and Van Reenen, 1999; Hall, 2002; Hall, 2008). Most of these papers use data on investment and cash flows and measure the effects of financial obstacles on innovation indirectly through the sensitivity between the latter and the former. This strand of the literature highlights that the intrinsic degree of uncertainty that characterizes innovation projects, together with their complexity, makes firms less likely to invest in innovation in the absence of financial availability (Hottenrott and Peters, 2012). Other recent contributions in this line use innovation survey data and provide direct information on the role of financial obstacles. Most of these studies are based on data from the European Community Innovation Survey (CIS) and Canadian data. Tourigny and Le (2004) study the perception of these obstacles among Canadian SMEs. Savignac (2008) finds that financial constraints and weak access to credit significantly reduce the likelihood of introducing new innovations, while Canepa and Stoneman (2007) find that the effects of credit constraints vary between sector and dimension of firms in the United Kingdom. Mancusi and Vezzulli (2010, 2013) measure the effects of financial constraints in R&D investment in Italy. An important feature of innovation survey data that attracted attention of scholars to this area of study is that it allows for a direct measure of the perception of obstacles by the firms. In this line, Mohnen and Rosa (2001) try to explain why Canadian firms perceive the obstacles to innovation differently. Galia and Legros (2004) study the perception of obstacles and complementarities in France.

More recent studies widened the scope of the analysis as they included in the picture obstacles not related to finance such as market structure, demand uncertainty, and lack of skilled personnel, among others (Iammarino, Sanna-Randaccio, and Savona, 2009; D'Este et al., 2012; D'Este, Rentocchini, and Vega-Jurado, 2014; Segarra-Blasco, García-Quevedo, and Teruel-Carrizosa, 2008; Pellegrino and Savona, 2017). Methodologically, there has been a turning point in the literature with the definition of the "relevant sample" of firms willing to innovate. A large part of the empirical literature including studies mentioned above finds a counterintuitive positive correlation between innovative behavior and obstacles to innovation (Mohnen and Rosa, 2001; Baldwin and Lin, 2002; Galia and Legros, 2004). Each of these studies tried to make sense of these counterintuitive findings in different ways, but they all converge in the concept of "revealed barriers," which implies that the more a firm participates in the innovation process, the more aware of the obstacles it becomes. However, recent papers (D'Este et al., 2012; Pellegrino and Savona, 2017) provide a more convincing mechanism to tackle this issue and generate consistent results, which involves excluding the firms not willing to innovate from the sample used in the empirical exercises. In the next section, we explain the construction of the relevant sample in this paper following this procedure.

Another important feature of recent literature that analyzes the role of a broad measure of obstacles and that we will address in the present study is the inclusion of the concept of "systemic failure." This concept arises when considering that not only financial barriers but also many other factors hinder innovation efforts. Consequently, the problem is not concentrated in a particular sector (e.g., financial markets), but expanded along the economy and the national system of innovation as a whole. In that sense and according to Coad, Pellegrino, and Savona (2016), "the presence of barriers to innovation is not just the result of a 'market failure' problem, rather it might be associated with particular conditions that represent 'systemic failures' for firms, which are difficult to overcome and might be seriously detrimental to their innovation and productivity performance, making the topic of substantial policy relevance." Following D'Este, Rentocchini, and Vega-Jurado (2014), we define systemic failures in terms of the extent to which institutional factors weaken the capabilities of the firms to engage in innovative activities. Systemic failures to innovation include: (i) the lack of institutional support for innovation; (ii) the lack of information on technological and market opportunities for innovation; (iii) the lack of an adequate infrastructure; and (iv) market structure factors.

Finally, regarding obstacles to innovation in Latin America, the evidence is scarce. Álvarez and Crespi (2015) use innovation surveys to measure the effect of financial constraints on innovation using a sample of Chilean firms. They find that financial barriers are quantitatively important, especially for firms operating in the services sector. Mohan, Stroble, and Watson (2017) measure the effects of obstacles on innovation propensity, intensity, innovation outcomes, and labor productivity using a sample of Caribbean firms. They find that cost, knowledge, market, and policy obstacles hamper engagement in innovation activities, innovation investment, and innovation outcomes. However, they do not find that obstacles reduce labor productivity.

3. Data and Methodology

3.1 Dataset

The data used in this paper comes from national Innovation Surveys (IS). IS are one of the largest-scale surveys gathering information on innovation behavior and outcomes. The IS in Uruguay has been carried out every three years since 1998, and is conducted by the National Bureau of Statistics (INE) as a request by the National Research and Innovation Agency of Uruguay (ANII). The first waves only included firms in the manufacturing industry. Since the 2004–06 wave, the IS has included firms from some services sectors.

The universe of study is firms that employed at least five people or had sales greater than or equal to 120 million pesos (current USD 4.2 million) in the period. Since 2004 the IS includes the following sectors (based on ISIC Rev.4): manufacturing; electricity, gas, steam, and air-conditioning supply; water supply, sewerage, waste management and remediation activities; transportation and storage; accommodation and food service activities; information and communication; professional, scientific, and technical activities; administrative and support service activities; and human health and social work activities. Table A1 in the Appendix shows the sectoral composition of the firms.

The empirical analysis will be based on a panel data of firms from the IS observed in all periods: 2004–06, 2007–09, 2010–12, 2013–15 (balanced panel). The panel data comprises a set of general information (main industry of affiliation, turnover, employment, and founding year) and a broader set of innovation variables measuring the firms' engagement in innovation activity, economic measures of the effects of innovation, subjective evaluations of factors hampering or fostering innovation, cooperative innovation activities, organizational innovation, and marketing. While general information on the firm was requested for each year in the surveys of 2010–12 and 2013–15 and for the last year of the survey for 2004–06 and 2007–09, innovation engagement variables are requested for the whole period. Therefore, while for the continuous variables we have eight years of information, the innovation-related variables are requested in such a fashion that we can only build a four-period panel. In order to adjust the span of the variables, we take the 2010–12 and 2013–15 averages of the general information variables when necessary so that we have four periods of data for them.

3.2 Sample Selection of Innovative Firms

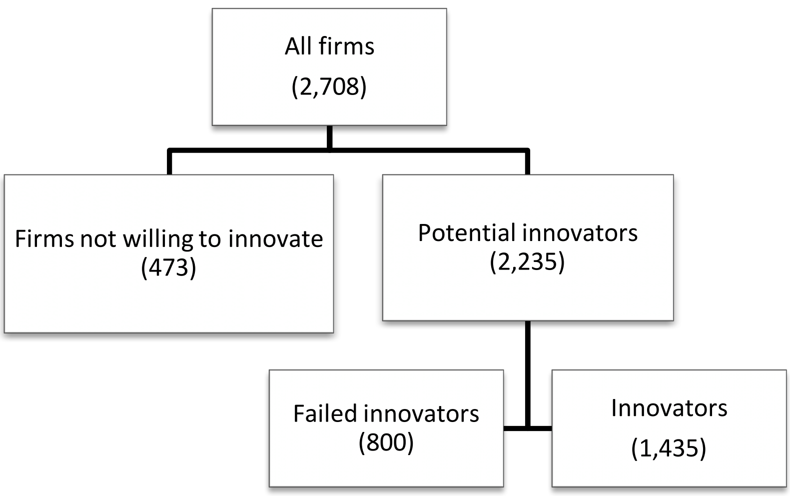
As mentioned above, the definition of the relevant sample of firms to be included in the empirical analysis has become a milestone in the literature of barriers to innovation. Savignac (2008), D'Este et al. (2012), Blanchard et al. (2012), and Pellegrino and Savona (2017) have shown that filtering out firms that do not want to innovate removes the positive correlation found between firms' innovation efforts and obstacles to innovation found in earlier papers such as Baldwin and Lin (2002) and Iammarino, Sanna-Randaccio, and Savona (2009). Hence, we will follow these recent developments and confine our analysis to the relevant sample of potential innovators that either engaged in innovation activities (reported non-zero innovation investment) or reported at least one barrier to innovation of "high importance." Three categories of firms were identified in terms of their innovative status:

1. Innovative firms: reported non-zero innovation investment regardless of whether they faced obstacles to innovate
2. Failed innovators: reported at least one barrier as important but did not report innovation investment
3. Firms not willing to innovate: did not report any barriers nor do they engage in innovation activities

In order to correctly estimate the sign and size of the relationship between innovation and barriers to innovation, the relevant sample included innovative firms and failed innovators, and excluded firms not willing to innovate. The raw database includes 690 firms and 2,760 firm-year observations. We exclude from these firms 11 publicly owned companies because, as Table A2 in the Appendix shows, they are much larger than the rest of the firms and also because the fundamentals of innovation investment spending in state-owned companies differs from private companies so the effects of barriers to innovation can be expected to be different as well.[1] After excluding publicly owned firms and observations that do not fall under the relevant sample, we end up with a panel of 2,235 firm-year observations that fall under one of the three categories defined above. Figure 1 shows the distribution of the observations regarding their status in the sample. Almost 83 percent (2,235) of total observations are included in the relevant sample. Within the innovative sample of firms, 1,435 reported investments in innovation activities while 800 declared to have faced at least one barrier to innovation while they did not engage in innovation activities.

It is important to stress that even though we correct for this known source of bias, other sources of endogeneity may emerge, for example, if successful innovators and failed innovators value the importance of obstacles to innovation differently. Also, it is important to note that, as in most micro-panels that follow enterprises along the years, our sample shows a moderate bias towards larger firms that survive along the four periods of the IS. Therefore, the results should be interpreted accordingly. Next, we detail our definitions of the barriers to innovation to be included in the empirical analysis.

Figure 1: Selection of the Relevant Sample



Source: Author's elaboration.

[1] In Uruguay, state-owned enterprises are an important part of the government instruments to execute public policy and are mostly monopolies. Therefore, the rationale of the innovation decisions in these firms and the obstacles faced by them may not be comparable with those of the firms in the private sector.

3.3 Obstacles

The IS questionnaire asks about 14 different obstacles to innovation. Firms are asked to respond in a 1 to 4 Likert-type scale if each obstacle was of irrelevant, low, medium, or high importance in the process of trying to perform innovation activities, with 1 being high importance and 4 irrelevant. In this paper we will define that a firm declares the obstacle is present if it is declared as being of high importance.

Note that the questionnaire asks about a broad number of factors that may have affected the innovation process. Using all of these separately would result in the construction of 14 obstacles variables. However, we choose to work a more parsimonious approach and build five dummy variables that take the value of 1 if firms faced barriers to innovation related to: 1) financial factors, 2) knowledge factors, 3) market size and structure factors, 4) institutional STI factors, and 5) context.

1. Financial obstacles: Dummy = 1 if the firm indicates the following barriers as being of high importance: cost of finance, excessive economic risks, return period of investment risks, and 0 otherwise.
2. Knowledge obstacles: Dummy = 1 if the firm indicates high importance in the following barriers: lack of qualified personnel, lack of information on technology, lack of information on markets, organizational rigidity, poor cooperation possibilities with other firms/institutions, and 0 otherwise.
3. Market size and structure obstacles: Dummy = 1 if the firm indicates the following barriers as being of high importance: reduced market size, few technological opportunities of the sector, and 0 otherwise.
4. Institutional STI obstacles: Dummy = 1 if the firm indicates the following barriers as being of high importance: insufficient development of institutions related to science and technology, poor intellectual property system, and 0 otherwise.
5. Context obstacles: Dummy = 1 if the firm indicates the following barriers as being of high importance: inadequate infrastructure, macroeconomic instability, and 0 otherwise.

3.4 Econometric Model and Empirical Implementation

The methodology builds largely on Crespi and Zuñiga (2012) and Mohan, Stroble, and Watson (2017). Given that our goal is to measure the effect of obstacles to innovation on innovation propensity, innovation intensity, innovation outputs, and labor productivity, we need a model that captures the complex relationships between these variables. Therefore, we adapt the CDM model (Crepon, Duguet, and Mairesse, 1998) with the explanatory variables used in the recent literature of obstacles to innovation. The model consists of a system of five equations linking a firm's innovation activities investments to its innovation output, and its innovation output to productivity. The CDM model allows us to deal with the selection bias in the innovation effort that results from the definition of the relevant sample, as the firms that invest in innovation activities can be thought of as a non-random sample of the firms. Empirically, we estimate the model sequentially in three steps. We begin by modeling the firms' innovation effort *IE** by:

$$IE^{*} = \beta_1 Z + \beta_2 X_1 + \varepsilon_1 \quad (1)$$

where IE^{*} is a latent variable accounting for desired expenditures in innovation activities, Z the vector of obstacles to innovation defined above, and X_1 a vector of other covariates that explain expenditure in innovation activities. We proxy innovation effort using (log) total expenditure in innovation activities per worker as our dependent variable but we also distinguish between (log) expenditure in tangible activities per worker (expenditure in machinery, hardware, and software for innovation) and (log) expenditure in intangible activities (R&D, technology transfers, industrial design and engineering, organizational design, training, and market research). Next, we introduce a selection equation that models the probability of observing investment in innovation activities:

$$ID = \begin{cases} 1 \; if \; ID^{*} = \beta_1 Z + \beta_2 X_2 + \varepsilon_2 > \alpha \\ 0 \; if \; ID^{*} = \beta_1 Z + \beta_2 X_2 + \varepsilon_2 < \alpha \end{cases} \quad (2)$$

where *ID* is a binary variable that equals 1 if a firm reports investment in innovation activities greater than zero and 0 otherwise. ID^{*} is a latent variable modeling the firm's innovation decision which materializes if it is above the threshold level α and where Z is a vector of barriers to innovation and X_2 are vectors of covariates affecting the innovation investment decision analogous to the ones in the previous equation.

As we only observe the amount invested for firms willing to engage in innovation activities, we combine equations (1) and (2) and write:

$$IE = \begin{cases} IE^{*} = \beta_1 Z_i + \beta_2 X + \varepsilon_1 \text{ if ID} = 1 \\ 0 \; if \; ID = 0 \end{cases} \quad (3)$$

Assuming that the error terms ε_1 and ε_2 are bivariate normal distributed with zero mean, $\sigma_2 = 1$ and correlation coefficient $\rho_{\varepsilon 2 \varepsilon 1}$ we estimate the system of equations (2) and (3) as a type II Tobit model.

The next equation provides the link between investment in innovation activities and innovation results through the so-called "knowledge production function" (Griliches, 1979; Pakes and Griliches, 1984) where the predicted values of the innovation effort enter as one of the covariates in the equation:

$$IO = \gamma IE^{*} + \beta_1 Z + \beta_3 X_3 + u_i \quad (4)$$

where *IO* is an innovation output and *IE** the predicted innovation effort from the previous step. We define three types of innovation outputs: a general definition of innovation, technological innovation (product or process innovation), and non-technological innovation (organizational and marketing). The last equation of the model relates labor productivity with innovation results:

$$y = \varphi IO^{*} + \beta_1 Z + \beta_4 X_4 + u \quad (5)$$

where *y* is labor productivity measured by the natural logarithm of sales per employee,[2] *IO** the predicted innovation output from equation (4), and *Z* the vector of obstacles to innovation.

We estimate this recursive model in the following way. First, we estimate the generalized Tobit model of equations (2) and (3) using the Heckit procedure. Note that in this case we are not using a panel-data specific method of estimation and we are not including fixed effects; therefore, we control for individual heterogeneity that could bias the estimation as a function of observables following Mundlak's (1978) approach including the within means of the explanatory variables (i.e., the average values of the covariates across all time periods for every firm) as regressors. The covariates included in the estimation of (2) and (3) are the natural logarithm of the firm's size measured by the number of employees, the natural logarithm of the firm's age, the proportion of highly skilled workers, and a dummy for exporter status, with the caveat that we remove the (log) size from the innovation effort equation in order to achieve identification because the investment is already scaled for size. We estimate equation (4) using a random-effects probit model also including the within means of the

[2] Unfortunately, we do not have access to data on capital assets and therefore we cannot measure total factor productivity or include the capital per worker as a covariate as in other papers using the CDM model.

covariates to control for individual time invariant characteristics of the firms. The additional regressors included in (4) are (log) size, exporter status, and proportion of highly skilled workers. Finally, we estimate equation (5) using a fixed-effects regression. We use the broad definition of innovator in order to calculate the predicted value of *IO* in equation (5). In this equation, the only additional covariate is the (log) size. All regressions include year dummies. In each stage we run the regressions for all the firms in the relevant sample and repeat the exercise separately for the industry and services sector.

3.5 Descriptive Evidence

Tables 1 and 2 show descriptive statistics for the firms in the different sample categories and by sector respectively. In the top panel we describe the dependent variables in the regressions. The data indicate that the average firm in the sample invests USD 2,113 per year per worker in total innovation activities; however, note that the sub-sample of innovators spends twice that figure. Investment in tangible activities is the most important expenditure as it accounts for 85 percent of total investment. It is important to note the large standard deviations in the productivity variable, an issue that will be addressed below. Process innovation is the one with a higher prevalence; 70 percent of innovators successfully introduce these types of innovations. Also note that 98 percent of the firms engaged in innovation activities successfully introduce a technological or non-technological innovation. In the middle panel we report the descriptive statistics for the obstacle's dummy variables, as defined above. The most interesting result lies in the proportion of firms declaring facing obstacles in each sub-sample of the innovative firms. The fact that innovators declare consistently lower obstacles than failed innovators is in line with the concept of *deterring barriers* (D'Este et al., 2012), as a larger involvement in innovation activities is associated with lower barriers to innovation. Regarding the explanatory variables, innovators appear older, larger, more export oriented, and with a higher proportion of skilled workers within the firms. Results in Table 2 indicate that failed innovators and innovators in the industry sector appear to be more constrained by obstacles than firms in the services sector.

Table 1: Descriptive Statistics by Firm Category in the Sample

Dependent Variables	Total Sample Mean	SD	n	Non-Innovator Mean	SD	n	Failed Innovator Mean	SD	n	Innovator Mean	SD	n
Total investment in innovation activities	2,113	19,088	2,708	0	0	473	0	0	800	3,988	26,083	1,435
Investment in Tangibles	1,796	18,990	2,708	0	0	473	0	0	800	3,390	25,988	1,435
Investment in Intangibles	316	1,195	2,708	0	0	473	0	0	800	597	1,590	1,435
ln (Total investment in innovation activities)	6.48	2.00	1,435							6.48	2.00	1,435
ln (Investment in Tangibles)	6.29	2.08	1,174							6.29	2.08	1,174
ln (Investment in Intangibles)	5.03	2.43	1,120							5.03	2.43	1,120
Productivity	128,014	326,805	2,708	175,669	537,678	473	100,311	281,159	800	127,751	247,452	1,435
ln (Productivity)	10.98	1.21	2,708	10.99	1.38	473	10.70	1.24	800	11.13	1.11	1,435
Innovator	52%	50%	2,708	0	0	473	0	0	800	98%	14%	1,435
Product	27%	44%	2,708	0	0	473	0	0	800	50%	50%	1,435
Process	37%	48%	2,708	0	0	473	0	0	800	70%	46%	1,435
Organizational	23%	42%	2,708	0	0	473	0	0	800	43%	50%	1,435
Marketing	11%	31%	2,708	0	0	473	0	0	800	21%	40%	1,435
Obstacles												
Financial obstacles	36%	48%	2.708	0	0	473	59%	49%	800	36%	48%	1,435
Knowledge obstacles	32%	47%	2.708	0	0	473	50%	50%	800	33%	47%	1,435
Market obstacles	38%	49%	2.708	0	0	473	60%	49%	800	38%	49%	1,435
Institutional STI	14%	34%	2.708	0	0	473	22%	41%	800	14%	35%	1,435
Context	21%	41%	2.708	0	0	473	34%	48%	800	20%	40%	1,435
Explanatory Variables												
Age	40.43	21.31	2.708	37.46	19.31	473	38.62	19.16	800	42.42	22.83	1,435
Size	218.38	484.21	2.708	156.58	296.39	473	148.29	285.66	800	277.82	600.57	1,435
ln (Age)	3.56	0.53	2.708	3.50	0.51	473	3.53	0.52	800	3.60	0.55	1,435
ln (Size)	4.57	1.19	2.708	4.30	1.15	473	4.26	1.14	800	4.83	1.16	1,435
Exporter	0.39	0.49	2.708	0.34	0.48	473	0.30	0.46	800	0.46	0.50	1,435
High education	7.87	11.79	2.708	7.69	13.75	473	5.92	9.89	800	9.02	11.93	1,435

Source: Authors' calculations.

Table 2: Descriptive Statistics by Sector and Category

Dependent Variables	Non-Innovator						Failed Innovator						Innovator					
	Industry			Services			Industry			Services			Industry			Services		
	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
Total investment in innovation activities	0	0	226	0	0	247	0	0	426	0	0	374	3,954	10,567	860	4,038	39,148	575
Investment in Tangibles	0	0	226	0	0	247	0	0	426	0	0	374	3,217	10,300	860	3,651	39,094	575
Investment in Intangibles	0	0	226	0	0	247	0	0	426	0	0	374	737	1,863	860	387	1,023	575
ln (Total investment in innovation activities)													6.93	1.82	860	5.81	2.07	575
ln (Investment in Tangibles)													6.76	1.89	715	5.56	2.16	459
ln (Investment in Intangibles)													5.42	2.25	676	4.43	2.56	444
Productivity	249,757	742,209	226	107,881	202946	247	114,694	350,084	426	83,929	170,830	374	154,435	287,358	860	87,842	163,520	575
ln (Productivity)	11.28	1.39	226	10.73	1.31	247	10.95	1.14	426	10.42	1.29	374	11.44	0.94	860	10.68	1.17	575
Innovator	0	0	226	0	0	247	0	0	426	0	0	374	98%	14%	860	98%	15%	575
Product	0	0	226	0	0	247	0	0	426	0	0	374	53%	50%	860	46%	50%	575
Process	0	0	226	0	0	247	0	0	426	0	0	374	76%	42%	860	61%	49%	575
Organizational	0	0	226	0	0	247	0	0	426	0	0	374	38%	49%	860	52%	50%	575
Marketing	0	0	226	0	0	247	0	0	426	0	0	374	19%	39%	860	23%	42%	575
Obstacles																		
Financial obstacles	0	0	226	0	0	247	64%	48%	426	53%	50%	374	40%	49%	860	30%	46%	575
Knowledge obstacles	0	0	226	0	0	247	50%	50%	426	50%	50%	374	33%	47%	860	33%	47%	575
Market obstacles	0	0	226	0	0	247	61%	49%	426	59%	49%	374	43%	50%	860	31%	46%	575
Institutional STI	0	0	226	0	0	247	23%	42%	426	21%	41%	374	17%	37%	860	9%	29%	575
Context	0	0	226	0	0	247	38%	49%	426	30%	46%	374	25%	43%	860	14%	34%	575
Explanatory Variables																		
Age	40.82	19.67	226	34.38	18.48	247	42.99	19.43	426	33.64	17.60	374	45.91	20.82	860	37.21	24.66	575
Size	108.78	129.94	226	200.32	386.11	247	100.70	142.96	426	202.51	382.07	374	180.81	256.18	860	422.91	876.18	575
ln (Age)	3.58	0.54	226	3.42	0.47	247	3.65	0.50	426	3.39	0.50	374	3.71	0.51	860	3.45	0.57	575
ln (Size)	4.17	1.04	226	4.43	1.23	247	4.09	0.98	426	4.46	1.28	374	4.66	1.00	860	5.09	1.33	575
Exporter	0.51	0.50	226	0.19	0.39	247	0.44	0.50	426	0.13	0.34	374	0.62	0.49	860	0.22	0.41	575
High education	5.24	8.88	226	9.94	16.73	247	4.00	4.61	426	8.11	13.27	374	6.49	7.21	860	12.80	15.94	575

Source: Authors' calculations.

4. Results

Table 3 shows the results for the joint estimation of equations (2) and (3).[3] While the top panel shows the marginal effects for the determinants of innovation propensity, the bottom panel exhibits the results for innovation investment. In the latter equation, the reported estimates are marginal effects corrected for the probability of being selected into the sample.[4] The first column shows the results for the total amount of investment in innovation activities and the total firms in the relevant sample considered in this paper; that is, considering firms from both industry and service sectors. The following columns disaggregate by sector and type of innovation activities. Column 1 indicates that four of the five barriers to innovation considered affect innovation propensity, as their coefficient turns out negative and significant from zero. These results suggest that, in general, barriers to innovation reduce from 6.5 percent to 14 percent a firm's probability of engaging in innovative activities in Uruguayan firms. Also, the results of the determinants of (log) innovation expenditure per employee indicate that barriers to innovation related to financing, knowledge, market, and context reduce 47 percent to 89 percent total innovation expenditures. Considering the full (relevant) sample, the same obstacles affect both the propensity and intensity. In this case, institutional factors do not have a significant effect on firms' behavior.

The results shown in columns 2 and 3 are quite interesting. While the coefficients of financial, market, and knowledge obstacles are significant for both sectors, context obstacles only affect the propensity to invest in innovation activities in the services sector. On the other hand, the amount invested appears to be constrained by the context factors in firms in both industry and services sectors. Then, unlike the results for the full sample, when distinguishing between sectors we find that in the manufacturing industry, context factors are not relevant in the decision of whether to invest in innovation, but they are a consideration in terms of how much to invest. This result may suggest that policy instruments targeted for the services sectors may focus on engaging firms in innovation, while for the industry matching grants or subsidies to increase investment may provide better results (besides other programs aiming to cope with the other significant barriers).

Finally, columns 4 to 5 report the coefficients and marginal effects for the entire sample considering the decision to engage in different innovation activities (tangibles and intangibles). In this case, results should be analyzed with more scrutiny because

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[3] In this section we show the results for the relevant sample; in Tables A3 to A5 in the Appendix we include the results for the full sample. As can be seen, filtering out the firms not willing to innovate significantly improves the estimations.

[4] This is performed with the *yexpected* option in the *margins* postestimation command in STATA.

they differ between types of innovation activity and equation considered (top and bottom panel). Regarding the probability of investing, the financial, market, knowledge, and context obstacles affect tangible investments. On the other hand, only financial, market, and context obstacles reduce the probability of spending in intangible activities. This result is similar to Álvarez and Crespi (2015), who find that financial constraints are particularly important in intangible investments in innovation. Regarding innovation investment for tangibles, the pattern of significant coefficients for innovation barriers is maintained with respect to the upper panel. Financial and knowledge barriers also affect investment in this kind of innovation activity. The results in Table 3 confirm the importance of both financial and nonfinancial barriers. With respect to the other covariates, only size turns significant to explain innovation propensity and intensity.

Table 3: Effect of Barriers to Innovation on Innovation Propensity and Intensity
(relevant sample)

ID (probability of investing in innovation IE > 0)	(1) All firms	(2) Industry	(3) Services	(4) Tangibles	(5) Intangibles
Financial Obstacles	-0.137***	-0.129***	-0.139***	-0.091***	-0.122***
	(0.019)	(0.024)	(0.029)	(0.021)	(0.020)
Knowledge Obstacles	-0.086***	-0.074***	-0.093***	-0.062***	-0.032
	(0.019)	(0.024)	(0.029)	(0.021)	(0.021)
Market Obstacles	-0.100***	-0.085***	-0.134***	-0.105***	-0.072***
	(0.019)	(0.024)	(0.028)	(0.020)	(0.021)
Institutional Obstacles	0.007	0.029	-0.046	0.009	0.042
	(0.026)	(0.031)	(0.043)	(0.028)	(0.028)
Context Obstacles	-0.065***	-0.040	-0.099***	-0.071***	-0.052**
	(0.022)	(0.026)	(0.036)	(0.024)	(0.024)
ln (Age)	-0.009	-0.024	-0.084	0.022	0.014
	(0.055)	(0.075)	(0.077)	(0.057)	(0.057)
ln (Size)	0.080***	0.137***	0.080***	0.085***	0.065***
	(0.010)	(0.017)	(0.013)	(0.010)	(0.011)
Exporter	0.043	0.028	0.056	-0.006	0.071
	(0.043)	(0.053)	(0.066)	(0.046)	(0.045)
High education	0.001	0.005*	0.000	0.002	0.001
	(0.001)	(0.003)	(0.002)	(0.001)	(0.002)
IE (log of innovation expenditure per employee)					
Financial Obstacles	-0.891***	-0.898***	-0.817***	-0.620***	-0.642***
	(0.142)	(0.181)	(0.232)	(0.148)	(0.128)
Knowledge Obstacles	-0.595***	-0.448**	-0.531**	-0.456***	-0.225*
	(0.145)	(0.183)	(0.231)	(0.151)	(0.131)
Market Obstacles	-0.549***	-0.591***	-0.668***	-0.575***	-0.111
	(0.141)	(0.200)	(0.237)	(0.145)	(0.127)
Institutional Obstacles	0.023	0.160	-0.475	-0.032	0.302*
	(0.197)	(0.254)	(0.333)	(0.205)	(0.177)
Context Obstacles	-0.466***	-0.371*	-0.540*	-0.410**	-0.161
	(0.168)	(0.216)	(0.312)	(0.177)	(0.154)
ln (Age)	0.177	-0.416	-0.316	0.303	0.135
	(0.382)	(0.781)	(0.584)	(0.386)	(0.332)

ln (Size)	0.427***	1.125***	0.342***	0.425***	0.280***
	(0.053)	(0.165)	(0.061)	(0.054)	(0.048)
Exporter	0.204	0.093	0.261	-0.077	0.294
	(0.313)	(0.344)	(0.356)	(0.319)	(0.276)
High education	0.008	0.037	0.001	0.004	0.004
	(0.010)	(0.025)	(0.009)	(0.010)	(0.009)
Observations	2,235	1,286	949	2,235	2,235
Number of obs	2235	1286	949	2235	2235
Censored obs	800	426	374	1061	1115
Log pseudo likelihood	-4,207	-2,374	-1,716	-3,856	-3,915
LR test of independence	24.62***	22.57***	31.36***	31.90***	11.89***
Year fixed effects	YES	YES	YES	YES	YES
Within mean of independent variables	YES	YES	YES	YES	YES

Source: Authors' calculations.
Notes: ***, **, and * indicate significance at the 1 percent, 5 percent, and 10 percent levels respectively. Robust standard errors in parentheses. In columns 1, 2, and 3 the dependent variables are log expenditure in total innovation activities and a binary indicator that takes the value of 1 if the investment of the firm is greater than 0. Columns 4 and 5 are analogous for the investment in tangibles and intangibles activities respectively.

Table 4 illustrates the results for the estimation of the knowledge production function. We estimate the models for the general definition of innovator and then for each type of innovation (technological and non-technological innovators). For the regressions considering the full sample, we find that the predicted innovation investment is significant to explain innovation results. However, in the regressions by sector the coefficient becomes non-significant. Also, the likelihood ratio test for the significance of the individual component of the variance (rho) is significant for all the specifications, indicating that the random effects specification is suitable for the data, as opposed to the pooled estimator. Similar to the results for innovation intensity, we find that four obstacles (cost, market, knowledge, and context) reduce the probability of introducing successful innovations (Column 1). The presence of obstacles to innovation translates to a reduction of 6.5 percent to 12 percent in the firms' innovation outcomes. When considering each type of innovation separately, the results differ. While both technological and non-technological innovations are constrained by financial and market obstacles, product and process innovations are also affected by knowledge obstacles, whereas organizational and marketing innovations are affected by context obstacles. This last result is in line with Schubert (2010), who finds that market environment affects organizational innovation.

Columns 4 to 6 and 7 to 9 show the results individually for firms in the industry and services sectors respectively. The probability of introducing new innovations for the firm in the manufacturing sector is affected by the financial, market, knowledge, and context obstacles. When considering technological innovation this last coefficient becomes non-significant. Surprisingly, non-technological innovations do not appear to be constrained by any of the obstacles considered here. Finally, columns 7 to 9 report the marginal effects for the firms in the services sector. Technological innovators face the same obstacles as in the industry sector, but market coefficient was greater in the service sector, while non-technological innovators face financial and market constraints. This last result is interesting as non-technological innovations in the services sectors are not constrained by "soft" barriers such as knowledge but by market and financial obstacles. Regarding the rest of the covariates, the number of employees is significant to explain the introduction of innovations throughout all the specifications. The proportion of highly skilled workers enhances innovation outcomes for firms in the industry sector, while firms more export-oriented are more likely to introduce innovations in the services sector.

Table 4: Effect of Barriers to Innovation on Innovation Outcomes *(relevant sample)*

	All Firms			Industry			Services		
	(1) Innovator	(2) Technological Innovator	(3) Non-Technological Innovator	(4) Innovator	(5) Technological Innovator	(6) Non-Technological Innovator	(7) Innovator	(8) Technological Innovator	(9) Non-Technological Innovator
IE predicted	0.065**	0.087***	0.003	0.010	0.002	0.039	0.032	0.005	0.047
	(0.032)	(0.033)	(0.033)	(0.044)	(0.045)	(0.045)	(0.056)	(0.058)	(0.057)
Financial Obstacles	-0.092***	-0.080***	-0.072***	-0.114***	-0.115***	-0.034	-0.103***	-0.097***	-0.108***
	(0.021)	(0.022)	(0.022)	(0.027)	(0.028)	(0.029)	(0.033)	(0.035)	(0.036)
Knowledge Obstacles	-0.067***	-0.061***	0.002	-0.070***	-0.073***	0.005	-0.086***	-0.078**	0.001
	(0.021)	(0.022)	(0.023)	(0.027)	(0.028)	(0.029)	(0.032)	(0.035)	(0.035)
Market Obstacles	-0.123***	-0.099***	-0.044**	-0.090***	-0.081***	-0.028	-0.181***	-0.138***	-0.072**
	(0.019)	(0.020)	(0.021)	(0.025)	(0.026)	(0.027)	(0.027)	(0.030)	(0.032)
Institutional Obstacles	0.007	0.026	0.015	0.021	0.026	0.047	-0.024	0.008	-0.041
	(0.025)	(0.027)	(0.028)	(0.031)	(0.033)	(0.034)	(0.042)	(0.046)	(0.049)
Context Obstacles	-0.055**	-0.029	-0.051**	-0.056**	-0.025	-0.041	-0.075**	-0.082**	-0.054
	(0.022)	(0.024)	(0.025)	(0.028)	(0.030)	(0.031)	(0.037)	(0.041)	(0.043)
Exporter	0.056	0.071*	0.020	0.005	0.007	-0.054	0.126**	0.159***	0.121**
	(0.037)	(0.038)	(0.040)	(0.049)	(0.051)	(0.052)	(0.055)	(0.057)	(0.061)
ln (size)	0.070***	0.060***	0.050***	0.143***	0.143***	0.056***	0.053***	0.037**	0.053***
	(0.013)	(0.013)	(0.012)	(0.021)	(0.022)	(0.021)	(0.018)	(0.019)	(0.018)
High education	0.002	0.000	0.003**	0.007**	0.003	0.008***	0.001	-0.001	0.002
	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)	(0.003)	(0.001)	(0.002)	(0.002)
Observations	2,235	2,235	2,235	1,286	1,286	1,286	949	949	949
LR rho=0	116.5***	139.00***	32.30***	33.96***	52.42***	9.191***	54.82***	48.60***	21.51***
Year fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
Within mean of independent variables	YES	YES	YES	YES	YES	YES	YES	YES	YES

Source: Authors' calculations.

Notes: ***, **, and * indicate significance at the 1 percent, 5 percent, and 10 percent levels respectively. In each column the dependent variable is a dummy that takes the value of 1 if the firm successfully introduced an innovation and 0 otherwise.

Table 5 shows the result for the labor productivity equation. Columns 1 to 3 show the results for the full (relevant) sample, where we find positive significant signs for the knowledge and market coefficients. We argue that these results may be caused by the large dispersion of the dependent variable, as shown in the previous section. In Columns 4 to 6 we show the results using a winsorized sample removing observations below the 5th and above the 95th percentile of the distributions. We find that innovation propensity had a positive but not significant impact on labor productivity. Also, there is no evidence that obstacles affect our dependent variable. These results are similar to Mohan, Stroble, and Watson (2017) for Caribbean firms.

Table 5: Effects of Barriers to Innovation on Labor Productivity

	Full Sample			Trimmed Sample		
	(1)	(2)	(3)	(4)	(5)	(6)
	All firms	Industry	Services	All firms	Industry	Services
IO predicted	0.939**	0.711	0.750	0.604	0.646	0.145
	(0.430)	(0.612)	(0.620)	(0.483)	(0.729)	(0.658)
Financial Obstacles	0.067	0.019	0.074	0.033	0.023	0.002
	(0.056)	(0.079)	(0.082)	(0.063)	(0.095)	(0.087)
Knowledge Obstacles	0.111**	0.110*	0.069	0.082*	0.110	0.013
	(0.045)	(0.062)	(0.066)	(0.050)	(0.074)	(0.069)
Market Obstacles	0.115*	0.096	0.080	0.074	0.080	0.012
	(0.061)	(0.086)	(0.089)	(0.069)	(0.102)	(0.095)
Institutional Obstacles	0.038	0.063	-0.025	0.023	0.063	-0.069
	(0.034)	(0.041)	(0.059)	(0.036)	(0.045)	(0.061)
Context Obstacles	0.031	-0.002	0.058	0.011	-0.014	0.040
	(0.042)	(0.056)	(0.066)	(0.046)	(0.065)	(0.069)
ln (Size)	-0.555***	-0.461***	-0.628***	-0.466***	-0.390***	-0.533***
	(0.049)	(0.073)	(0.068)	(0.055)	(0.083)	(0.074)
Constant				12.005***	11.877***	12.381***
				(0.289)	(0.429)	(0.404)
Observations				1,912	1,077	835
R-squared	0.334	0.294	0.395	0.325	0.284	0.394
Year fixed effects	YES	YES	YES	YES	YES	YES

Source: Authors' calculations.
Notes: ***, **, and * indicate significance at the 1 percent, 5 percent, and 10 percent levels respectively. In all columns the dependent variable is the natural logarithm of labor productivity.

So far we have analyzed the results of the estimations for each stage of the model separately, which can become cumbersome as the tables include several columns analyzing different sets of firms and/or innovation activities. In order to ease the interpretation of the results, we include a table with the summary of findings by estimation procedure and barrier. In summary, Table 6 helps us to draw the following conclusions relating to the relevance of each barrier in the innovation process:

- Financial obstacles appear as the most important factors hampering innovation because it is significant across almost all estimations.
- Knowledge and market obstacles affect innovation propensity to a similar extent. However, market obstacles appear more significant in the case of innovation outcomes.
- Institutional obstacles are non-significant.
- Context obstacles are more important constraints to engagement and investment than explaining failure in achieving innovation outputs.

Table 6: Summary of Findings by Obstacle and Estimated Equation

	Innovation Propensity	**Innovation Intensity**	**Innovation Outcomes**	**Labor Productivity**
Financial	Significant throughout all the specifications	Significant throughout all the specifications	Significant throughout all the specifications except for industry non-technological innovation	Non-significant
Knowledge	Significant throughout all the specifications except for intangibles	Significant throughout all the specifications	Significant in all cases for general and technological innovation; non-significant in any case for non-technological innovation	Non-significant
Market	Significant throughout all the specifications	Significant throughout all the specifications except for intangibles	Significant throughout all the specifications except for industry non-technological innovation	Non-significant
Institutional	Non-significant	Non-significant	Non-significant	Non-significant
Context	Significant throughout all the specifications except for industry firms	Significant throughout all the specifications except for intangibles	All firms: significant for general and non-technological innovation; industry: significant for general innovation; services: significant for general and technological innovation	Non-significant

Source: Authors' calculations.
Note: Coefficient significant at the 1 percent, 5 percent, and 10 percent levels.

5. Concluding Remarks

This paper presents evidence that barriers to innovation have a substantial effect on innovation propensity, intensity, and outcomes. On the other hand, we do not find evidence that barriers affect labor productivity. In terms of the objectives of the study, we do not find evidence that institutional obstacles are important factors hampering innovation; however, it is important to note that the rest of the financial and nonfinancial barriers considered are significant. The results show that obstacles affect the innovative behavior of firms in the industry and services sectors similarly. We confirm that different barriers hamper investment in tangible and intangible activities.

The presence of obstacles to innovation translates to a reduction of 47 percent to 89 percent in the firms' innovation efforts; also, it translates to a reduction of 6.5 percent to 14 percent in the firms' innovation propensity. Financial, market, knowledge, and context obstacles are the most important factors reducing the probability to engage in innovation activities and the amount invested. On the other hand, the empirical analysis indicates that barriers related to systemic failure of STI institutions are not significant. While expenditure in equipment is affected mainly by the four obstacles mentioned above, investment in R&D and other intangible activities are mostly constrained by market and financial barriers. Regarding innovation outcomes, we find that financial and market factors are the most important, whereas the role of context and knowledge barriers varies between types of innovation. Finally, we do not find effects of obstacles to innovation on labor productivity.

The evidence presented throughout this paper should serve as an input for future policymaking. From a national system of innovation perspective, it is crucial for policymakers to understand which obstacles slow down the firms' innovation process (Chaminade and Edquist, 2006). As Galia, Mancini, and Morandi (2012) point out, different types of obstacles and innovator profiles demand different interventions. Our results suggest that a systemic approach to overcome several barriers is needed. In order to increase engagement in innovation activities and expenditure intensity, a mixture of instruments focusing in financial, market, and knowledge is needed (innovation widening) along with expanding the reach of innovative activities and increasing innovation outcomes (innovation deepening). Regarding the economic sectors, the results suggest that policies can be applied broadly.

Regarding financial barriers, these issues have been addressed in the last decade by ANII through a set of programs promoting innovation activities in the productive sector. A recent impact evaluation by Bukstein et al. (2017) shows evidence of a crowding-in effect for beneficiaries of ANII's programs, as treated firms spend two to three times more in R&D and three to four times more in innovation activities than the control group. However, the scope of ANII is still small at the national level with less than 1 percent of national firms engaging in this type of program. Therefore, the main challenge for policy actions in this regard is to increase the reach of instruments to foster innovation with focus in intangible investments. Also, promoting cooperation between firms might help reduce the costs of innovation projects as shown by Antonioli, Marzucchi, and Savona (2017). Concerning the market structure–related obstacles, this is the most challenging obstacle to overcome as its reduced size is an intrinsic characteristic of the Uruguayan market. We therefore infer that the lack of demand is decisive for firms to give up innovation projects. In this sense, the policy actions should focus on insertion of firms into global value chains or help in placing their products in international markets. With respect to knowledge-related obstacles, it is necessary to foster the link between academia and industry, for example, funding the training of highly qualified professionals and aiding their insertion in the productive sectors.

Finally, results indicate that policymakers should keep in mind that macroeconomic instability and uncertainty not only harms the economic performance through higher unemployment but also via preventing firms from engaging in innovation activities. In this regard, the results suggest that in times of economic downturn, policy instruments targeted for the services sectors may focus on engaging firms in innovation, while for the industry matching grants or subsidies to increase investment may provide better results (besides other programs aiming to cope with other significant barriers). Future research topics include studying the complementarities between the barriers and other questions such as the cooperation strategy of the firms in order to cope with innovation obstacles.

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Annex

Table A1. Sectoral Composition of the Firms in the Relevant Sample

Sector	N	Frequency (%)
Manufacture of food products	389	17.46
Growing of non-perennial crops	70	3.13
Growing of perennial crops	4	0.18
Plant propagation	57	2.59
Animal production	71	3.17
Mixed farming	49	2.23
Support activities to agriculture and post-harvest crop activities	39	1.74
Hunting, trapping, and related service activities	26	1.16
Printing and reproduction of recorded media	53	2.37
Manufacture of chemicals and chemical products	116	5.18
Silviculture and other forestry activities	96	4.29
Logging	66	2.95
Gathering of non-wood forest products	49	2.19
Support services to forestry	19	0.85
Manufacture of fabricated metal products, except machinery and equipment	40	1.79
Manufacture of computer, electronic, and optical products	7	0.31
Manufacture of electrical equipment	39	1.74
Manufacture of machinery and equipment not elsewhere classified	4	0.18
Manufacture of motor vehicles, trailers, and semi-trailers	25	1.16
Manufacture of other transport equipment	7	0.31
Fishing	20	0.89
Aquaculture	26	1.16
Repair and installation of machinery and equipment	12	0.54
Electricity, gas, steam, and air-conditioning supply	6	0.27
Water collection, treatment, and supply	3	0.13
Land transport and transport via pipelines	127	5.67
Water transport	18	0.8
Mining of hard coal	9	0.4
Mining of lignite	104	4.64
Postal and courier activities	10	0.45
Accommodation	62	2.77
Food and beverage service activities	22	0.98
Publishing activities	34	1.52
Motion picture, video and television program production, sound recording, and music publishing activities	3	0.13
Extraction of crude petroleum	48	2.14

Extraction of natural gas	30	1.34
Legal and accounting activities	8	0.36
Activities of head offices; management consultancy activities	13	0.58
Mining of iron ores	4	0.18
Mining of non-ferrous metal ores	6	0.27
Advertising and market research	34	1.52
Rental and leasing activities	12	0.54
Employment activities	35	1.56
Travel agency, tour operator, reservation service, and related activities	36	1.61
Security and investigation activities	55	2.46
Quarrying of stone, sand, and clay	25	1.12
Office administrative, office support, and other business support activities	27	1.21
Human health activities	220	9.78
Total	2,235	100

Table A2: Mean Differences between Public and Non-Public Companies in Innovation Investment and Size

	Non-Public	Public	Difference
Total investment in innovation activities (current USD)	434,413	14,278,844	-13,844,431***
Investment in R&D	24,202	989,629	-965,427***
Investment in equipment	381,460	11,267,171	-10,885,711***
Investment in other innovation activities	28,751	2,022,043	-1,993,293***
Size	231	2,100	-1,869***

Table A3. Effect of Barriers to Innovation on Innovation Propensity and Intensity

(full sample)

AI (probability of investing in innovation IE > 0)	(1) All	(2) Industry	(3) Services	(4) Tangibles	(5) Intangibles
Financial Obstacles	-0.017	-0.017	-0.012	0.007	-0.030
	(0.021)	(0.027)	(0.033)	(0.021)	(0.021)
Knowledge Obstacles	0.029	0.016	0.050	0.032	0.054***
	(0.021)	(0.028)	(0.032)	(0.021)	(0.021)
Market Obstacles	0.041**	0.039	0.009	0.005	0.031
	(0.020)	(0.027)	(0.031)	(0.020)	(0.020)
Institutional Obstacles	0.011	0.052	-0.067	0.014	0.044
	(0.029)	(0.036)	(0.049)	(0.029)	(0.028)
Context Obstacles	-0.026	0.000	-0.072*	-0.038	-0.021
	(0.025)	(0.030)	(0.041)	(0.025)	(0.024)
ln (Age)	-0.009	0.051	-0.129*	0.016	0.016
	(0.055)	(0.077)	(0.075)	(0.054)	(0.053)
ln (Size)	0.102***	0.150***	0.100***	0.097***	0.083***
	(0.010)	(0.017)	(0.012)	(0.010)	(0.010)
Exporter	0.023	0.025	0.030	-0.014	0.047
	(0.042)	(0.054)	(0.062)	(0.042)	(0.041)
High education	0.001	0.006**	-0.000	0.001	0.001
	(0.001)	(0.003)	(0.002)	(0.001)	(0.001)
IE (log of innovation expenditure per employee)					
Financial Obstacles	-0.110	-0.156	-0.052	0.013	-0.182
	(0.148)	(0.195)	(0.227)	(0.144)	(0.121)
Knowledge Obstacles	0.161	0.124	0.336	0.155	0.217*
	(0.150)	(0.194)	(0.226)	(0.146)	(0.121)
Market Obstacles	0.333**	0.233	0.154	0.102	0.353***
	(0.145)	(0.208)	(0.243)	(0.141)	(0.118)
Institutional Obstacles	0.057	0.325	-0.561*	0.019	0.296*
	(0.205)	(0.282)	(0.321)	(0.199)	(0.165)
Context Obstacles	-0.193	-0.089	-0.359	-0.201	-0.021
	(0.176)	(0.233)	(0.296)	(0.172)	(0.144)
ln (Age)	0.121	0.164	-0.602	0.233	0.116
	(0.371)	(0.723)	(0.567)	(0.356)	(0.297)
ln (Size)	0.549***	1.236***	0.435***	0.501***	0.356***
	(0.054)	(0.173)	(0.061)	(0.053)	(0.044)
Exporter	0.089	0.103	0.116	-0.124	0.184
	(0.297)	(0.360)	(0.347)	(0.287)	(0.242)
High education	0.006	0.041**	-0.001	0.004	0.002
	(0.009)	(0.019)	(0.009)	(0.009)	(0.008)
Observations	2,708	1,512	1,196	2,708	2,708
Number of obs	2708	1512	1196	2708	2708
Censored obs	1273	652	621	1534	1588
Log pseudo likelihood	-4682	-2625	-1943	-4191	-4217
LR test of independence	37.73	30.15	51.22	36.50	17.18
Year fixed effects	YES	YES	YES	YES	YES
Within mean of independent variables	YES	YES	YES	YES	YES

Note: ***, **, and * indicate significance at the 1 percent, 5 percent, and 10 percent levels respectively. Robust standard errors in parentheses. In columns 1, 2, and 3 the dependent variables are log expenditure in total innovation activities and a binary indicator that takes the value of 1 if the investment of the firm is greater than 0. Columns 4 and 5 are analogous for the investment in tangibles and intangibles activities respectively.

Table A4. Effect of Barriers to Innovation on Innovation Outcomes *(full sample)*

	All			**Industry**			**Services**		
	(1) Innovator	(2) Technological Innovator	(3) Non-Technological Innovator	(4) Innovator	(5) Technological Innovator	(6) Non-Technological Innovator	(7) Innovator	(8) Technological Innovator	(9) Non-Technological Innovator
IE predicted	0.102***	0.111***	0.024	0.024	0.028	0.044	0.067	0.039	-0.009
	(0.031)	(0.031)	(0.028)	(0.043)	(0.044)	(0.039)	(0.053)	(0.052)	(0.049)
Financial Obstacles	0.032	0.024	-0.005	0.007	-0.008	0.018	0.026	0.009	-0.025
	(0.022)	(0.022)	(0.020)	(0.029)	(0.029)	(0.027)	(0.035)	(0.035)	(0.033)
Knowledge Obstacles	0.049**	0.035	0.060***	0.030	0.017	0.043	0.056*	0.035	0.084***
	(0.022)	(0.022)	(0.020)	(0.029)	(0.029)	(0.027)	(0.034)	(0.034)	(0.031)
Market Obstacles	0.003	0.008	0.020	0.022	0.019	0.023	-0.034	-0.018	0.011
	(0.020)	(0.020)	(0.019)	(0.027)	(0.027)	(0.024)	(0.031)	(0.031)	(0.029)
Institutional Obstacles	0.013	0.031	0.020	0.031	0.035	0.053*	-0.033	0.006	-0.039
	(0.028)	(0.028)	(0.026)	(0.035)	(0.035)	(0.031)	(0.048)	(0.047)	(0.045)
Context Obstacles	-0.004	0.015	-0.025	-0.005	0.023	-0.019	-0.040	-0.047	-0.026
	(0.025)	(0.025)	(0.023)	(0.031)	(0.031)	(0.029)	(0.042)	(0.042)	(0.040)
Exporter	0.020	0.038	0.004	-0.020	-0.013	-0.056	0.068	0.101**	0.077
	(0.035)	(0.034)	(0.034)	(0.047)	(0.047)	(0.046)	(0.052)	(0.051)	(0.050)
ln (Size)	0.092***	0.080***	0.059***	0.156***	0.154***	0.065***	0.077***	0.058***	0.060***
	(0.013)	(0.013)	(0.011)	(0.022)	(0.023)	(0.019)	(0.017)	(0.017)	(0.016)
High education	0.001	-0.000	0.002**	0.007**	0.004	0.007***	-0.000	-0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)	(0.002)	(0.001)	(0.001)	(0.001)
Observations	2.708	2.708	2.708	1.512	1.512	1.512	1.196	1.196	1.196
LR rho=0	167.6***	186.4***	48.42***	75.39***	88.64***	12.36***	62.06***	59.38***	35.33***
Year fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
Within mean of independent variables	YES	YES	YES	YES	YES	YES	YES	YES	YES

Note: ***, **, and * indicate significance at the 1 percent, 5 percent, and 10 percent levels respectively. In each column the dependent variable is a dummy that takes the value of 1 if the firm successfully introduced an innovation and 0 otherwise.

Table A4. Effect of Barriers to Innovation on Labor Productivity *(full sample)*

	(1) All Firms	(2) Industry	(3) Services
IO predicted	1.308***	1.163*	1.155**
	(0.435)	(0.646)	(0.586)
Financial Obstacles	0.119**	0.092	0.118
	(0.057)	(0.083)	(0.078)
Knowledge Obstacles	0.158***	0.165**	0.130**
	(0.046)	(0.067)	(0.064)
Market Obstacles	0.168***	0.151	0.150*
	(0.063)	(0.092)	(0.086)
Institutional Obstacles	0.020	0.060	-0.063
	(0.037)	(0.047)	(0.060)
Context Obstacles	0.061	0.037	0.081
	(0.044)	(0.061)	(0.066)
ln (Size)	-0.596***	-0.470***	-0.680***
	(0.047)	(0.075)	(0.060)
Constant	12.228***	12.027***	12.440***
	(0.259)	(0.390)	(0.344)
Observations	2,708	1,512	1,196
R-squared	0.309	0.248	0.396
Year fixed effects	YES	YES	YES

Note: ***, **, and * indicate significance at the 1 percent, 5 percent, and 10 percent levels respectively. In all columns the dependent variable is the natural logarithm of labor productivity.